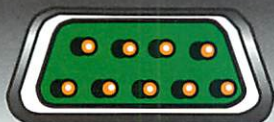


Interface and Supervisory Circuits

ISSUE 4

June, 1996



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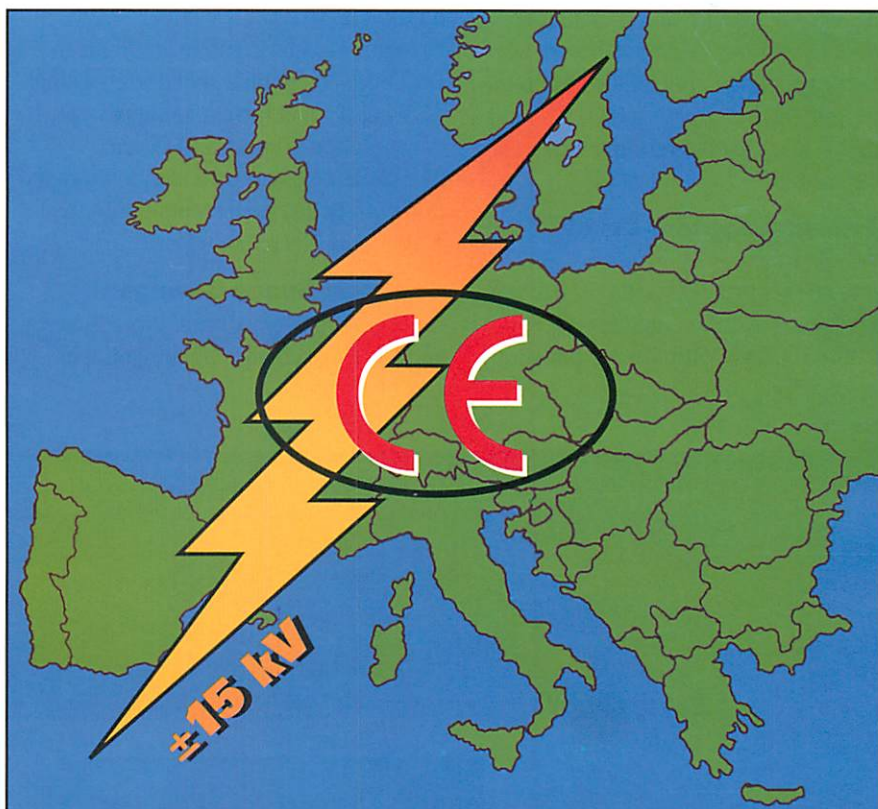
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The First RS-232 Transceivers To Meet European EMI and ESD Requirements



The ADM202E, ADM207E, ADM208E, ADM211E and ADM213E are the industry's first family of robust, RS-232 and V.28 interface transceivers which meet and exceed the stringent European Union (EU) directive on electromagnetic compatibility. Each provides ± 15 kV of ESD protection and compliance with EMI/EMC requirements.

The regulations demand that products for sale in the EU "be so constructed that they do not cause excessive electromagnetic interference and are not unduly affected by electromagnetic interference". It is expected that the EU standards will be adopted worldwide.

Conformance with the directive on electromagnetic compatibility requires that products must have a high level of intrinsic immunity to emissions from other sources, and must also limit their undesirable emissions to within very strict limits. Enclosed is general design information on the new IEC requirements which you'll want to keep on file.

You'll also learn how you can enable your interface designs and systems to be marketed in Europe with the new Analog Devices' ADM2xxE family of standards-compliant transceivers.

Analog Devices' new family of RS-232 transceivers opens you to the European market and provides your interface designs and systems with unmatched ruggedness.

Setting New Standards of Compliance

Every member of the ADM2xxE family is designed and tested to ensure the highest level of intrinsic immunity. On-chip ESD, EFT and EMI protection structures comply with IEC1000-4-2, IEC1000-4-3 and IEC1000-4-4 requirements. You're protected against Electrostatic Discharges to ±15 kV and Electrical Fast Transients to ±2 kV. Added benefits include latch-up protection and immunity to high RF field strengths, allowing operation in unshielded enclosures.

Maintaining System-Level Advantages

Despite all this protection, the ADM2xxE family doesn't sacrifice high speed. Fast slew rates coupled with low propagation

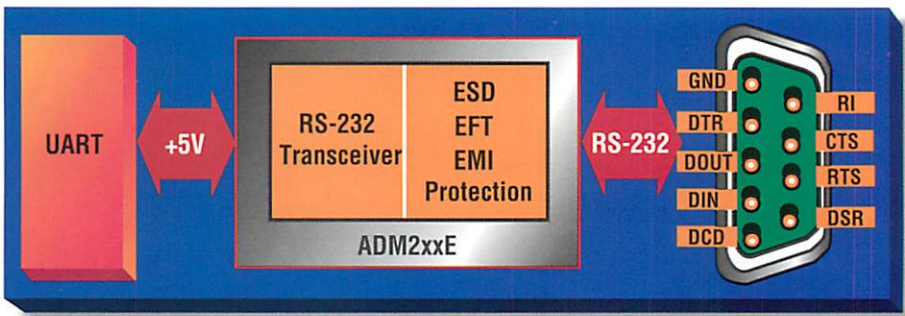


Figure 1: Typical PC RS-232 application

delay specifications permit data transmission up to 230 kbps under heavy capacitive loading. You're getting high LapLink®-compatible speed from a single +5 V supply and lowest-in-industry power consumption. The ADM211E and ADM213E also feature a shutdown function with power consumption less than 5 µW in the sleep mode.

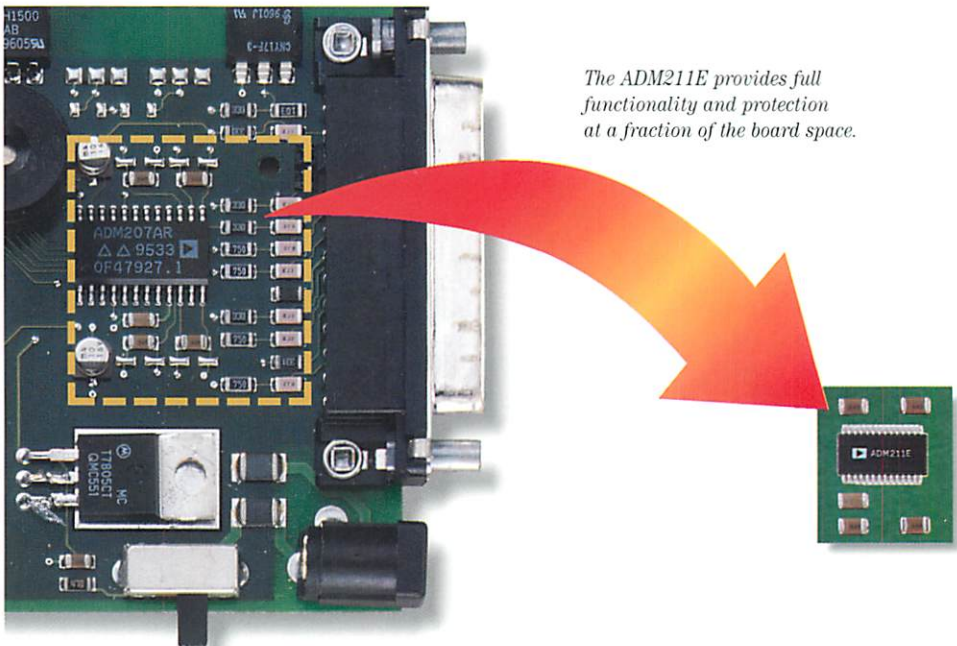
Cost and Space Savings

Design out costly external protection and filtering schemes by designing in

ADM2xxE family members. Conducted and radiated emissions will still meet EN55022, CISPR22 requirements for Information Technology Equipment (ITE) while you reduce system cost and save valuable board space. Now there's no need for high-frequency suppression filters, shielding components and filtered connectors. Fewer parts means higher reliability in TSSOP and other packaging with small (0.1 µF) capacitors.

Table 1

PRODUCT SELECTION TABLE								
Model	Drivers	Receivers	ESD Protection	Shutdown	# Receivers Active In Shutdown	Enable	Packages	Applications
ADM202E	2	2	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	General Purpose
ADM207E	5	3	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	Modem
ADM208E	4	4	±15 kV	No	—	No	DIP, SOIC, SSOP, TSSOP	Printer
ADM211E	4	5	±15 kV	Yes	0	Yes	SOIC, SSOP, TSSOP	Notebook, Laptop, PDA
ADM213E	4	3	±15 kV	Yes	2	Yes	SOIC, SSOP, TSSOP	Notebook, Laptop, PDA



The ADM211E provides full functionality and protection at a fraction of the board space.

The European Union EMC Directive

In May, 1989, the European Union published the 89/336/EEC Council Directive relating to electromagnetic compatibility of products placed on the market within the member states. This was followed by the 92/31/EEC amendment which delayed compulsory compliance until January 1, 1996. The directive applies to apparatus which is liable to cause electromagnetic disturbance or which itself is liable to be affected by such disturbance. Therefore, it applies to all electrical or electronic products. It goes beyond the FCC Class B requirement for emissions control since it also addresses immunity requirements.

Conformance with the EU directive on electromagnetic compatibility requires that products will:

- have a high level of intrinsic immunity to emissions from other sources
- limit their undesirable emissions to within very strict limits

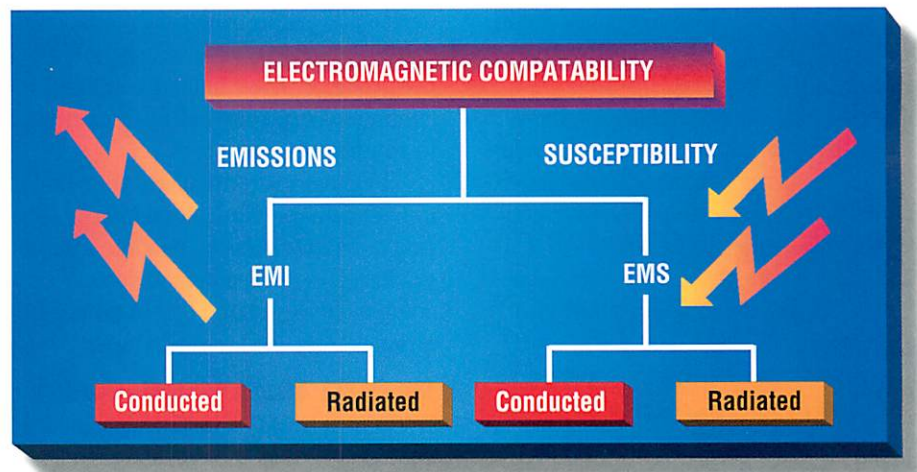


Figure 2: Electromagnetic compatibility

Table 2

Previous Standard	Current Standard	Section
IEC801	IEC1000-4	Electromagnetic Compatibility (EMC)
IEC801-1	IEC1000-4-1	Overview of Immunity Tests
IEC801-2	IEC1000-4-2	Electrostatic Discharge Immunity (ESD)
IEC801-3	IEC1000-4-3	Radiated Radio-Frequency Electromagnetic Field Immunity
IEC801-4	IEC1000-4-4	Electrical Fast Transients (EFT)

Basic IEC1000-4 immunity standards



The CE mark

The CE Mark

Responsibility to meet the regulations lies with the product manufacturer. Since January 1, 1996, electronic products sold in the EU must conform to the directive by displaying the Communaute Europeene (CE) marking. Use of the CE mark indicates that the equipment complies with the directive.

Standards

The standards to which a product must comply in order to achieve the CE mark fall into four categories: product standards; product family standards; generic standards; and basic standards. A product should be tested to its product standard if one exists. If not, it must be tested to the appropriate product family standard, or if this does not exist, the generic standard is applied.

Basic standards describe the phenomenon, specify the test equipment and detail the test setup and methodology. The basic standards applying to EMC immunity are IEC1000-4-x.

The immunity specification contained in the EU directive includes electrostatic discharge (ESD) testing. IEC1000-4-2 (previously IEC801-2) specifies compliance testing using two coupling methods, contact discharge and air-gap discharge. Contact discharge calls for a direct connection to the unit being tested. Air-gap discharge uses a higher test voltage but does not make direct contact with the unit under test. With air-gap, the discharge gun moves toward the unit under test, developing an arc across the air gap. Hence, the term “air-gap”. This method is influenced by humidity, temperature, barometric pressure, distance and rate of closure of the discharge gun. The contact-discharge method, while less realistic, is more repeatable and is gaining acceptance over the air-gap method.

Although very little energy is contained within an ESD pulse, the extremely fast rise time – coupled with high voltages – can cause failures in unprotected semiconductors. Catastrophic destruction can occur immediately as a result of arcing or heating. Even if catastrophic failure does not occur immediately, the

device may suffer from parametric degradation, which may result in degraded performance. The cumulative effects of continuous exposure can eventually lead to complete failure.

I/O lines are particularly vulnerable to ESD damage. Simply touching or plugging in an I/O cable can result in a static discharge, causing potential damage or complete destruction of the interface product connected to the I/O port.

MIL-STD 883B Test Method

Traditional ESD test methods, such as the MIL-STD 883B human-body model (method 3015.7) used by most semiconductor manufacturers, do not adequately test a product’s susceptibility to this type of real-world discharge. The traditional test was intended to evaluate a product’s susceptibility to ESD damage during han-

dling and board manufacture. Each pin is tested with respect to all other pins, simulating the type of discharges likely to occur during handling or with auto insertion equipment. There are some important differences between the traditional test and the IEC test. These differences are explained on page 3.

Table 3

ESD Test Method	R2	C1
MIL-STD 883B	1.5 kΩ	100 pF
IEC1000-4-2	330 Ω	150 pF

ESD discharge component values

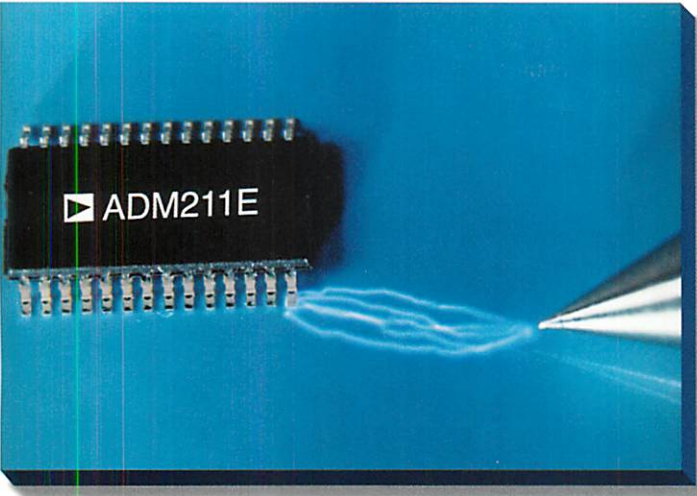
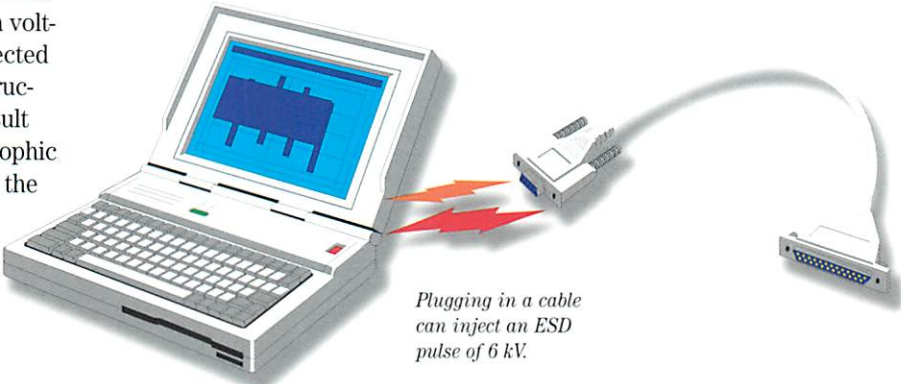


Figure 3: 15 kV electrostatic discharge in ADM211E

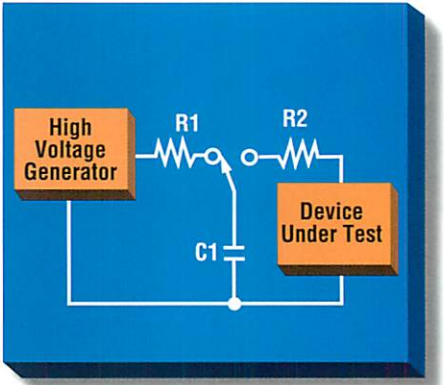


Figure 4: ESD test generator

IEC1000-4-2 vs. MIL-STD 883B

The IEC test is much more stringent in terms of discharge energy. Figure 4 shows a simplified schematic of the ESD test generator. Capacitor C1 is charged up to the required test voltage via R1. The energy in C1 is then discharged via R2 into the device under test. The peak current and discharge energy is determined by R2 and C1. Table 3 shows that for the IEC test, R2 is decreased from 1.5 k Ω to 330 Ω . This results in greater than 4X peak current increase. In addition, C1 increases by 50% from 100 pF to 150 pF.

Table 4

Level	Max Charge Voltage (kV)	Contact Discharge (kV)	Air Discharge (kV)
1	2	2	2
2	4	4	4
3	8	6	8
4	15	8	15

IEC1000-4-2 severity levels and test voltages

The IEC1000-4-2 test is carried out while power is applied to the device. This is unlike the MIL-STD 883B test where power is not applied. The process, therefore, checks for potential destructive latch-up which could be induced by the ESD transient. (It applies to I/O pins only.)

The IEC test is more representative of a real-world I/O discharge where the equipment is operating normally with power applied. For maximum peace of mind, however, both tests should be performed to ensure maximum protection in handling, manufacturing and later during field service.

ESD Testing Methods

The ADM2xxE family of products is tested using both the abovementioned test methods. All pins are tested with respect to all other pins per the MIL-STD 883B specification. In addition, all I/O pins are tested per the IEC test specification.

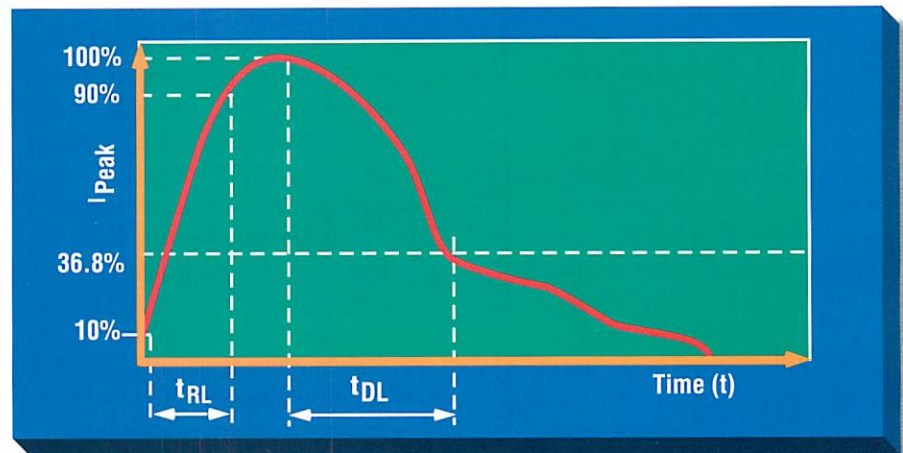
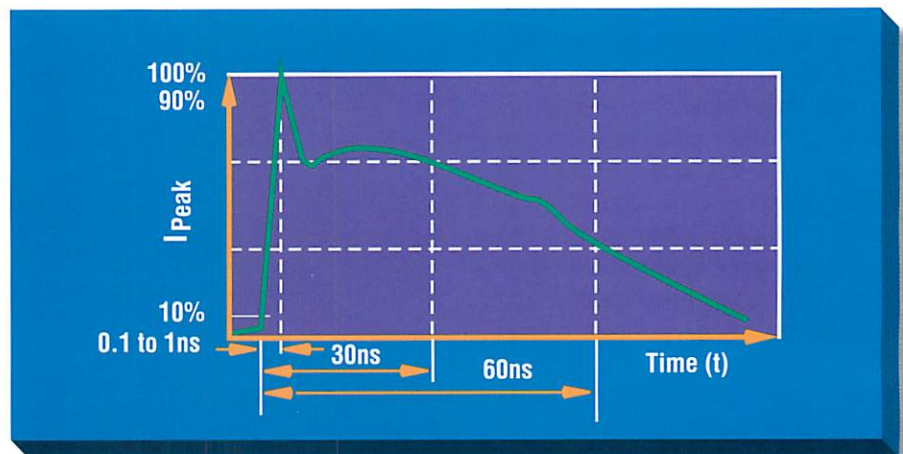
*Figure 5: Human body model discharge current waveform**Figure 6: IEC1000-4-2 contact discharge current waveform*

Table 4 shows the four levels of compliance defined by IEC1000-4-2. The ADM2xxE family meets the most stringent compliance level for both contact and air-gap discharge. This means that the products are able to withstand contact discharges up to 8 kV and air-gap discharges up to 15 kV.

Table 5

ESD Test Method	I/O Pins	Other Pins
MIL-STD 883B	15 kV	2.5 kV
IEC1000-4-2		
Contact	8 kV	-
Air	15 kV	-

ADM2xxE ESD results

Fast Transient Burst Immunity

IEC1000-4-4 (previously IEC801-4) covers electrical fast transient burst (EFT) immunity. Electrical fast transients occur as a result of arcing contacts in switches and relays. The tests defined in IEC1000-4-4 simulate the interference generated when, for example, a power relay disconnects an inductive load. A spark is generated due to the well-known back EMF effect. There is actually a burst of sparks as the relay contacts separate. The voltage appearing on the line consists of extremely fast transient bursts.

The fast transient burst test defined in IEC1000-4-4 attempts to simulate the interference resulting from this type of event and its waveform is illustrated in Figure 7. The waveform consists of a burst of 2.5 kHz to 5 kHz transients repeating at 300 ms intervals. These transients are coupled onto the I/O lines using a 1 meter capacitive clamp. Voltages as high as 2 kV are applied with fast transition times as illustrated in Figure 7. This can immediately destroy the integrated circuit connected to the I/O line or cause degradation in performance with delayed failure. The ADM2xxE uses a protection scheme designed to clamp the overvoltages to safe levels. This test is extremely severe since a combination of high voltages and fast edges merge onto the signal lines. In addition, the repetitive transients can often cause problems where single pulses do not. Destructive latch-up may be induced due to the high energy con-

tent of the transients. Note that the transients are applied while the interface products are powered up and are transmitting data. The EFT test applies hundreds of pulses with higher energy than ESD. In the worst case, transient current on an I/O line can be as high as 40 A. Test results are classified accordingly:

1. normal performance within specification limits
2. temporary degradation or loss of performance which is self-recoverable
3. temporary degradation or loss of function or performance which requires operator intervention or system reset
4. degradation or loss of function which is not recoverable due to damage

Test Results

The ADM2xxE products were tested under worst-case conditions using unshielded cable. Data transmission during the transient condition was corrupted, but it recovered immediately following the EFT event without user intervention. No damage or latch-up occurred even with voltages in excess of the specification requirements.

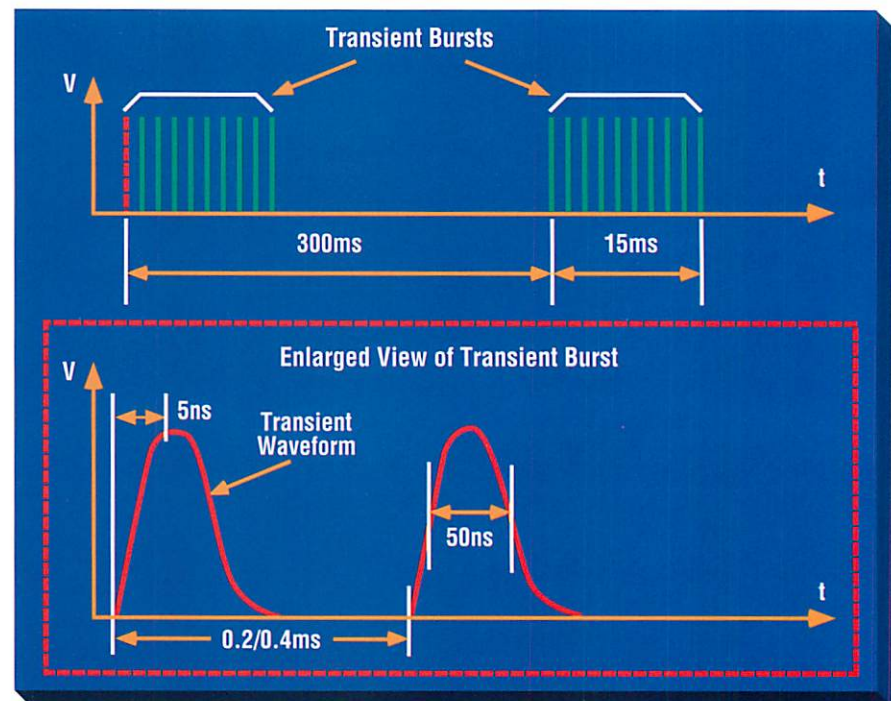


Figure 7: IEC1000-4-4 fast transient waveform

Electromagnetic Fields

IEC1000-4-3 (previously IEC801-3) describes the measurement method and defines the levels of immunity to radiated electromagnetic (EM) fields. It was originally intended to simulate the electromagnetic fields generated by portable radio transceivers or any other device which generates continuous wave-radiated electromagnetic energy. Its scope has since been broadened to include spurious EM energy, which can be radiated from fluorescent lights, thyristor drives, inductive loads, etc.

Testing for immunity involves irradiating the device with an EM field. There are various methods of achieving this. Testing integrated circuits is most conveniently achieved using some form of stripline cell. This device cell consists of two parallel plates with an electric field developed between them. A high-power RF amplifier generates the field which is swept in frequency from 80 MHz to 1 GHz. The device under test is placed within the cell and exposed to the elec-

tric field. A field strength monitor within the cell regulates the field strength, providing feedback so that constant field level versus frequency is maintained. There are three severity levels defined with field strengths ranging from 1 V/m to 10 V/m. Results are classified in a similar fashion to those for IEC1000-4-4:

1. normal operation
2. temporary degradation or loss of function which is self-recoverable when the interfering signal is removed
3. temporary degradation or loss of function which requires operator intervention or system reset when the interfering signal is removed
4. degradation or loss of function which is not recoverable due to damage

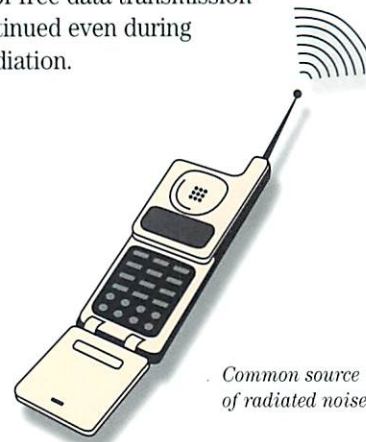
Table 6

Level	Field Strength (V/m)
1	1
2	3
3	10

EM classification levels

Test Results

The ADM2xxE family of products was tested at field strengths up to 30 V/m and showed no performance degradation. Error-free data transmission continued even during irradiation.



INTERNAL PROTECTION SCHEME ON RS-232 I/O LINES

ESD/EFT Transient Protection*

The ADM2xxE uses protective clamping structures on all inputs and outputs, which holds the voltage to a safe level and dissipates the energy present in ESD (Electrostatic) and EFT (Electrical Fast Transient) discharges. A simplified schematic of the protection structure is shown in Figure 8. Each RS-232 I/O line contains two back-to-back high-speed clamping diodes. During normal operation with maximum RS-232 signal levels, the diodes have no effect as one or the other is reverse-biased depending on the polarity of the signal. If, however, the voltage exceeds approximately ± 50 V, reverse breakdown occurs and the diodes begin conducting. The voltage is therefore clamped at this level. The diodes are large p-n junctions designed to handle the instantaneous current surge which can exceed several amperes.

The transmitter outputs and receiver inputs have a similar diode protection structure. The receiver inputs can also dissipate some of the energy through an internal 5 k Ω resistor to GND as well as through the protection diodes. The pro-

tection structure achieves ESD protection up to ± 15 kV and EFT protection up to ± 2 kV on all RS-232 I/O lines. Latch-up protection in accordance with JEDEC Standard 17 is also achieved.

** Patent Pending*

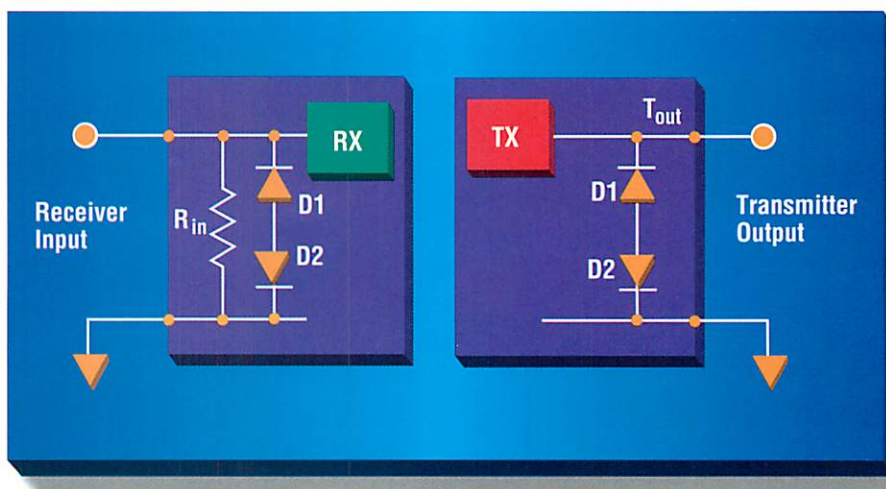


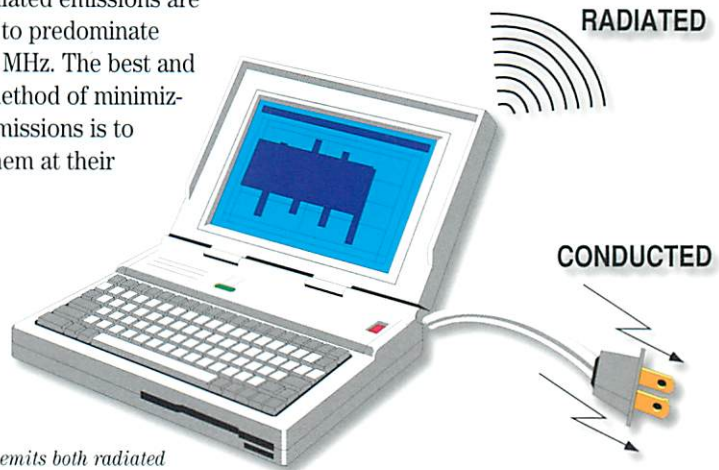
Figure 8: Internal protection structure

Emissions/Interference

EN55022, CISPR22 define the permitted limits of radiated and conducted interference from Information Technology (IT) equipment. The objective of the standard is to minimize the level of emissions both conducted and radiated.

Any circuit where there are switching signals will emit electromagnetic energy. High-frequency current transients can cause both conducted and radiated emissions. For ease of measurement and analysis, conducted emissions are assumed to predominate below 30 MHz

while radiated emissions are assumed to predominate above 30 MHz. The best and easiest method of minimizing the emissions is to reduce them at their source.



Equipment emits both radiated and conducted interference.

Radiated Emissions

Radiated emissions are measured at frequencies in excess of 30 MHz. RS-232 outputs, designed for operation at high baud rates while driving unshielded cables, can radiate high-frequency electromagnetic energy. In fact, emissions can start out being conducted on the power supply lines and become radiated if the frequency components are sufficiently high.

Fast RS-232 output transitions can radiate interference – especially when lightly loaded and driving unshielded cables. Charge-pump devices are also prone to radiating noise due to the high-frequency oscillator and high voltages being switched by the charge pump. The move to conserve board space

with smaller capacitors has resulted in employment of higher frequency oscillators in the charge pump design. This causes higher levels of both conducted and radiated emissions.

The ADM2xxE products feature RS-232 outputs with a controlled slew rate in order to minimize the level of

radiated emissions. However, they are fast enough to support data rates up to 230 kBaud.

Figure 9 shows a plot of radiated emissions vs. frequency. This shows that the levels of emissions are well within specifications without the need for any additional shielding or filtering.

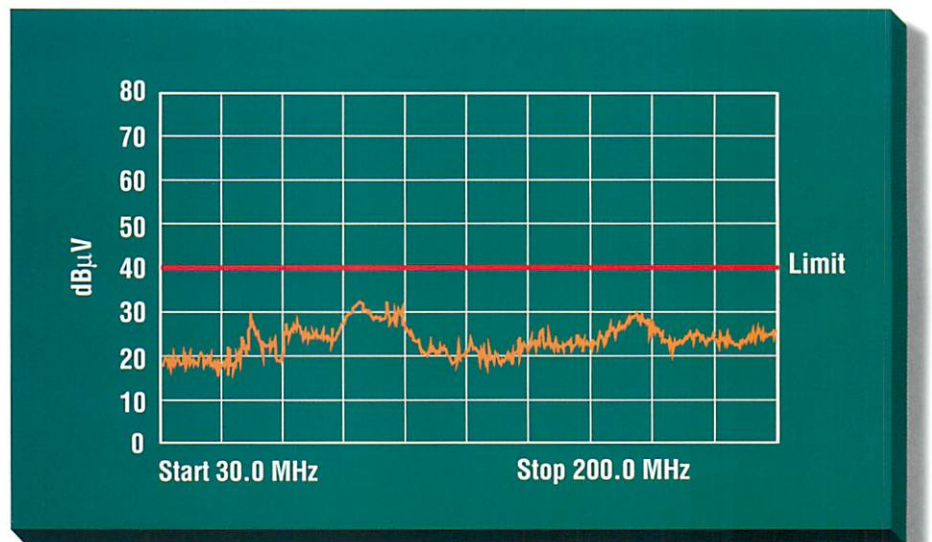


Figure 9: Radiated emissions frequency plot

Conducted Emissions

This is a measure of noise which gets conducted back onto the main power supply. In charge-pump based products, switching transients from the charge pump, which are 20 V in magnitude and containing significant energy, will result in conducted emissions. Emissions can also result from overlap in switch on-times in the charge pump voltage converter. As shown in the voltage doubler schematic (Figure 12), if S2 has not fully turned off before S4 turns on, the result is a transient current glitch between V_{CC} and GND which leads to conducted emissions. This process makes it important that the switches are carefully timed to ensure break-before-make switching under all operating conditions. Now instantaneous short-circuit conditions will not occur.

Figure 11 shows a typical plot of the conducted noise emitted by the ADM2xxE. The frequency components

resulting from the charge pump switching are clearly visible, but careful design makes sure that they are well below the maximum specification levels.

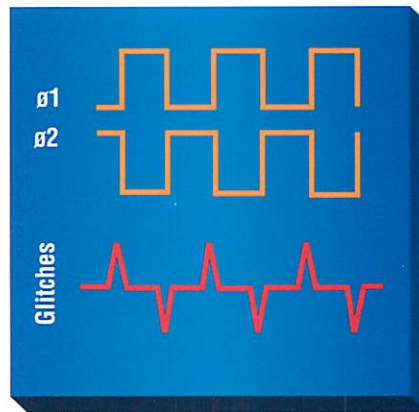


Figure 10: Charge pump switching glitches

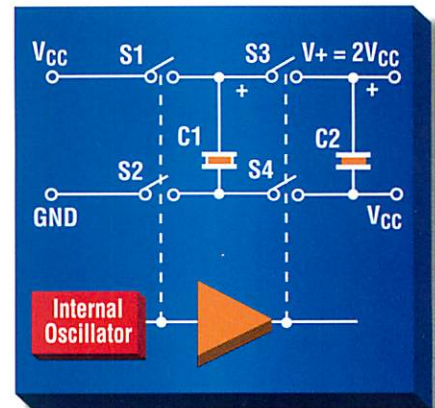


Figure 12: Charge pump voltage doubler

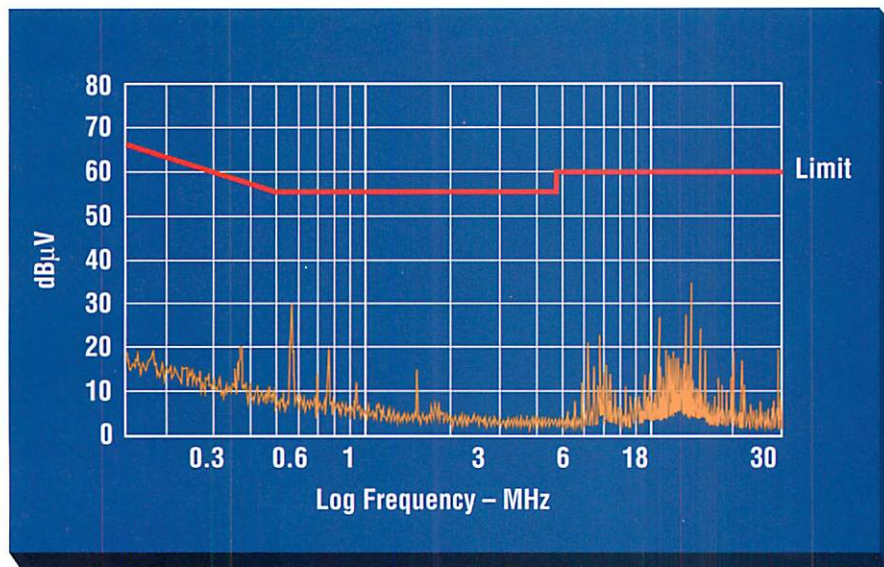
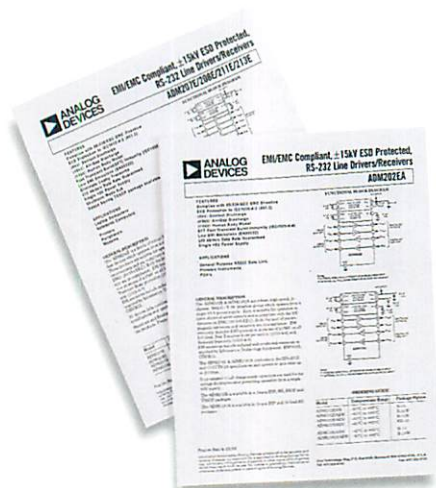


Figure 11: Conducted emissions frequency plot

CROSS REFERENCE CHART

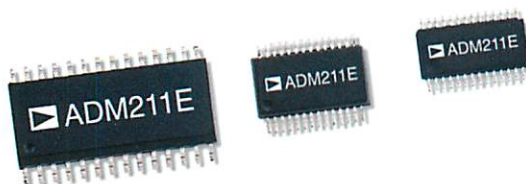
ADI	ADI Faxcode	ADI	ADI Faxcode	ADI	ADI Faxcode
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ADM202E	MAX202E 1992	ADM232A LT1181A	MAX232A 1539	ADM691 LTC691	MAX691 1563
ADM203	MAX203 1529	ADM233L	MAX233 1540	ADM692 LTC692	MAX692 1564
ADM206	MAX206 1531	ADM234L	MAX234 1540	ADM693 LTC693	MAX693 1565
ADM207	MAX207 1532	ADM236L	MAX236 1540	ADM694 LTC694	MAX694 1566
ADM207E	1991	ADM237L	MAX237 1540	ADM695 LTC695	MAX695 1567
ADM208	MAX208 1533	ADM238L	MAX238 1540	ADM696	MAX696 1568
ADM208E	1991	ADM239L	MAX239 1540	ADM697	MAX697 1569
ADM209	MAX209 1534	ADM241L	MAX241 1540	ADM698	MAX698 1570
ADM211	MAX211 1536	ADM242	MAX242 1552	ADM699 LTC699	MAX699 1571
ADM211E	MAX211E 1991	ADM485 LTC485	MAX485 1553	ADM705	MAX705 1865
ADM213E	MAX213E 1991	ADM560	MAX560 1556	ADM706	MAX706 1865
ADM222 LT1180	MAX222 1539	ADM561	MAX561 1557	ADM707	MAX707 1865
ADM223	MAX223 1540	ADM660 LTC1046	MAX660 1934	ADM708	MAX708 1865
ADM230L	MAX230 1540	ADM660 LTC1044	MAX1044	ADM709	MAX709 1893
ADM231L	MAX231 1540	ADM660	MAX7660	ADM1485 LTC1485	1527



ADM2xxE PACKAGING AND PRICING

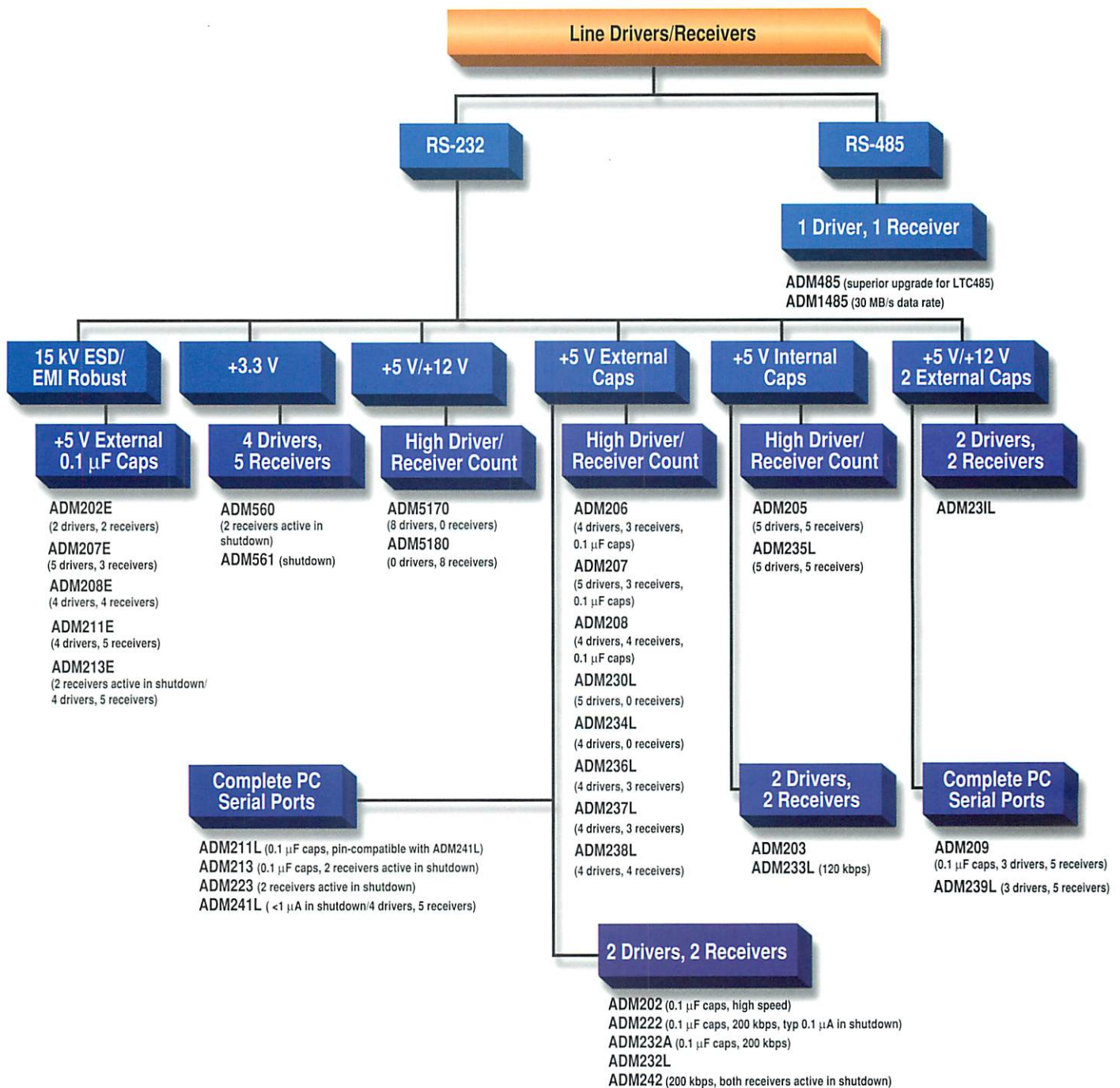
Packaging and Pricing

The ADM2xxE family is available in a variety of packages including DIP, SOIC, SSOP and TSSOP. SSOP gives a space savings of 57% over SOIC while TSSOP results in a further 28% saving. The TSSOP also saves on package height by 45%. Pricing begins at \$1.40, recommended resale, in 1,000 lot quantities, FOB U.S.A.



SOIC, SSOP, TSSOP packaging

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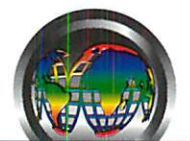
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